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Investigation of preparation and post processing effects on the topography of ultra-thin Al_2O_3 films

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Alumina (Al_2O_3) thin films are used in a wide range of micro and nanoelectronic applications including protective coatings and diffusion barriers. They have also been used as a series of insulating laminations in integrated magnetic inductors [1]. The thickness and surface state of Al_2O_3, however, is expected to affect exchange coupling, coercivity and anisotropy of the magnetic core of the inductor [2,3]. Additionally, the properties of ultra-thin films of Al_2O_3 are known to be affected by topography and electrostatics of the underlying substrate [4]. Here we report the interplay of substrate condition, deposition parameters, and post processing effects on the topography and electrical properties of Al_2O_3. We fabricated magnetic and nonmagnetic multilayers (Fig. 1) that emulate the vertical architecture and process steps of an integrated inductor. We employ a suite of scanning probe microscopy (SPM) techniques including atomic force microscopy (AFM), Kelvin Probe Force Microscopy (KPFM) and Scanning Spreading Resistance Microscopy (SSRM) using NTEGRA Spectra II^{TM} (NT-MDT Spectrum Instruments, Limerick, Ireland) to determine the presence of pinholes other defects and surface potentials. Additionally, we employ the following techniques; cross-sectional transmission electron microscopy (x-TEM), to verify thickness and structure evolution. Scanning electron microscopy (SEM) revealed islands and pinholes, the density of which was further investigated using an electroplating technique [5] and elemental mapping using energy dispersive X-ray (EDX) analysis. We have also developed a metal-insulator-metal (MIM) capacitor to compare nanoscale properties with macroscopic electrical properties of the ultra-thin films. The capacitor structure has been subject to impedance analysis to determine the electrical permittivity of the insulator. Such a suite of nano and macroscopic analysis allows us to find the interrelation of thickness variation, surface chemistry, topography and electrical properties and can be useful in optimising Al_2O_3 processing for use in laminated magnetic cores.

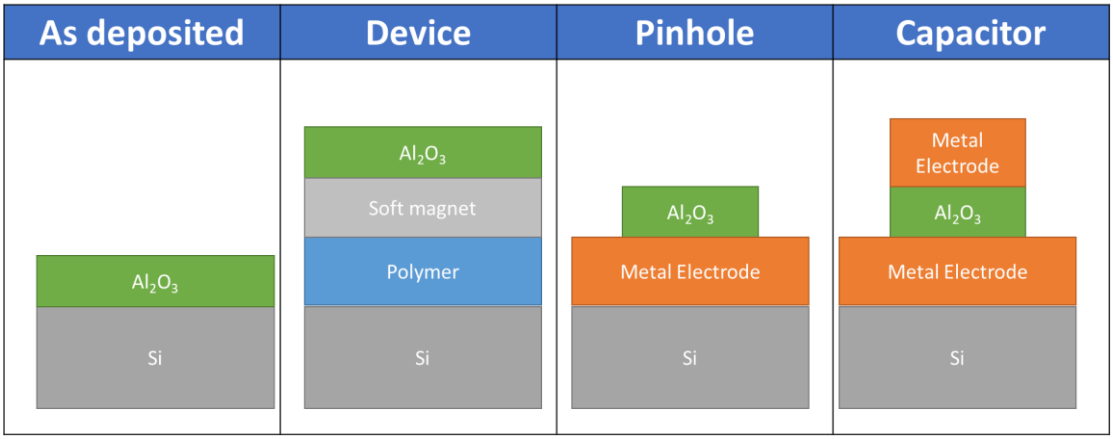

Figure 1. Test structures used for alumina characterisation.

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